

T06D08 – Elephants Toothpaste (Happy St. Patty's Day)

Hydrogen peroxide (H_2O_2) is a liquid at STP which does not have enough energy to overcome the E_a in order to decompose. Small changes in the E_a can be made by the addition of a catalyst such as UV radiation – which is why it's generally stored in a dark place or in a bottle with minimal transmittance of light. Other catalysts can be used to lower the E_a such as MnO_2 (manganese dioxide), potassium iodide (KI) and many transition metals. For this experiment I recommend the use of potassium iodide.

The overall reaction of the decomposition of hydrogen peroxide is as follows:



As has been discussed in HL material, the addition of a catalyst lowers the E_a by providing an alternative mechanism to the reaction. The elementary steps for the reaction are theoretical and the intermediates (unless rate determining) do not appear in the overall rate law of the equation.

For H_2O_2 the mechanism of catalysis using potassium iodide, KI, involves only the I^- ion meaning that an aqueous solution of KI will allow for a better reaction. The mechanism involves two steps as follows:



Second step regenerates the I^- ion (confirming that it acts as a catalyst since it returns to its original state). Since the first step is the slow step, it's also then the rate-determining step, and alone will make up the rate law.

Using the discussion from last class (IB 16.2), the coefficients of the elementary step can be used to determine the rate law:

$$\text{Rate} = k[\text{H}_2\text{O}_2][\text{I}^-]$$

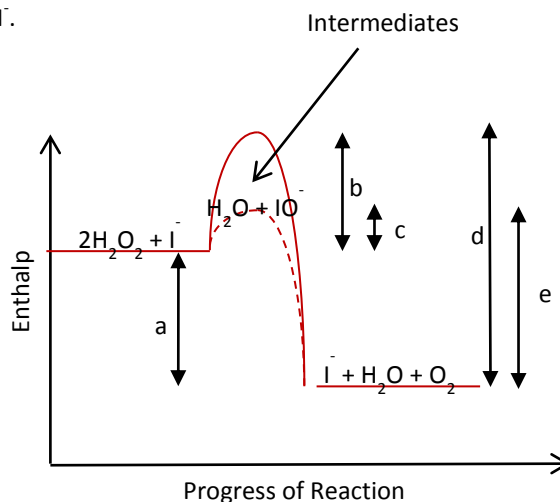
Thus, this reaction is first order with respect to both H_2O_2 and I^- .

The reaction is also notably exothermic.

Uncatalyzed Reaction ———

KI Catalyzed Reaction - - - - -

- Enthalpy (ΔH_{rxn}) stays the same
- Forward energy barrier (E_a) of un-catalyzed
- Forward energy barrier (E_a) of KI catalyzed
- Reverse energy barrier (E_a) of un-catalyzed
- Reverse energy barrier (E_a) of KI catalyzed



Have the students walk you through how you can confirm this rate law, but lead them to a set-up similar to the one below. If you complete each trial at the same time in several different 500mL or 1L grad cylinders, you can really see the relative rates of reaction. Have them put them in order of their predicted reaction rates so it's easy to visually see the reaction rates.

Be sure to cover the desk with large plastic bags. Fill each graduated cylinder with the H_2O_2 solution, about 5mL of liquid soap, and food coloring if desired. The last step will be to have 6 student volunteers pour KI(aq) into respective GC's and enjoy!

Volume of H_2O_2 (mL)	$[\text{H}_2\text{O}_2]$ (%)	Volume of I^-	$[\text{I}^-]$ (mol dm ⁻³)	Predicted Relative Rate
50.00	30.0	25.00	3.0	X24
50.00	15.0	25.00	3.0	X12
50.00	15.0	25.00	1.5	X6
50.00	15.0	25.00	1.0	X4
50.00	15.0	25.00	0.5	X2
50.00	7.5	25.00	0.5	X1

Read more:

http://wiki.answers.com/Q/Why_is_KI_a_catalyst_for_H2O2_decomposition_but_KBr_and_KCl_aren%27t#ixzz1GrQi9clr